(12) UK Patent Application (19) GB (11) 2 022 503 A

(21) Application No 7919543
(22) Date of filing
5 Jun 1979
(23) Claims filed
5 Jun 1979
(30) Priority data
(31) 912776
(32) 5 Jun 1978
(33) United States of America (US)
(43) Application published
19 Dec 1979
(51) INT CL[2] B28B 1/16 // B32B 13/02 13/04
(52) Domestic classification
B5A 1R150 1R214F 1R455 20T4 B11
B5N 1302 1304
(56) Documents cited
GB 1537161
G 1258288
(58) Field of search
B5A
(71) Applicant
United States Gypsum Company
101 South Wacker Drive
Chicago
Illinois 60606
United States of America
(72) Inventors
Donald Otto Baehr
David Graham Izard
(74) Agents
Reddie & Grose

(54) Fiber-reinforced cementitious sheets

(57) A fiber-reinforced cementitious sheet is formed by first co-mixing in an air current reinforcing fibers such as glass fibers, and cementitious mineral materials in finely particulate form such as calcium sulfate hemihydrate, both in substantially dry form, depositing the mixture on a moving foraminous surface by means of the air current to form a sheet, applying water as by spraying in at least an amount which is stoichiometrically sufficient to hydrate the calcium sulfate hemihydrate to the dihydrate form and to provide the necessary degree of plasticity to the mixture, densifying the sheet by compression, and setting and drying the sheet. A pair of sheets may be utilized as face sheets and, prior to setting, combined with a core formed of for example a calcium sulfate hemihydrate slurry, and the sheets and core then set and dried to form a paper-free gypsum board having excellent strength, surface hardness, and fire-resistant properties.

GB 2 022 503 A

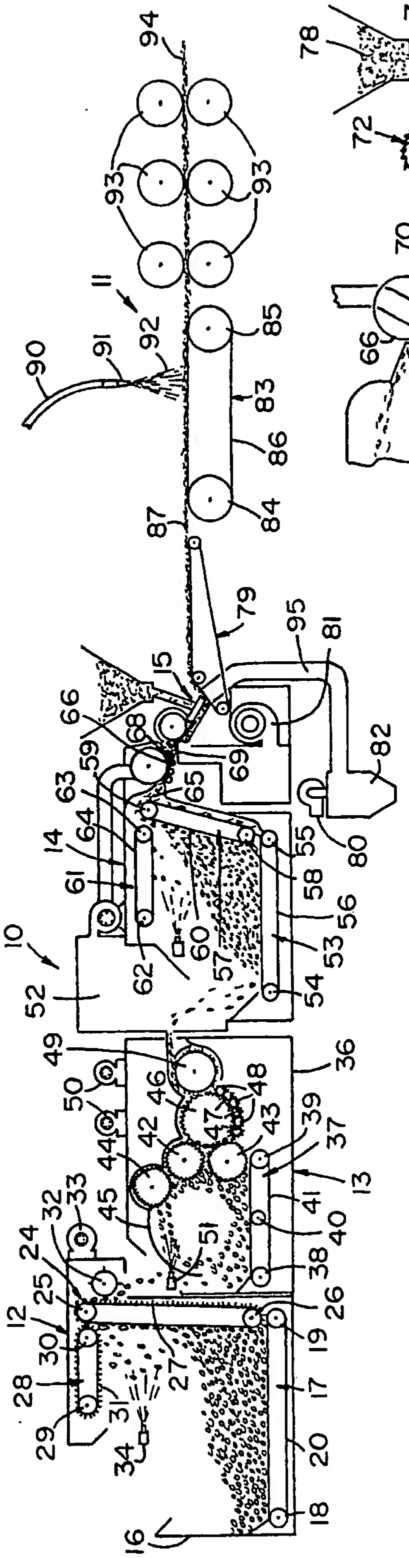

Fig. 1

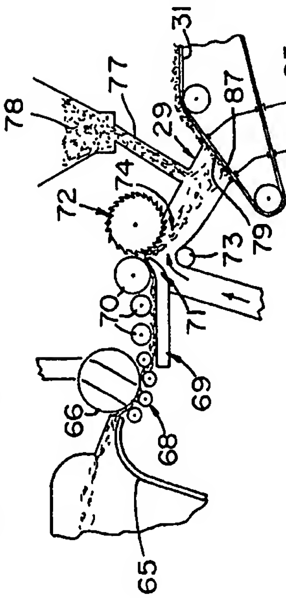

Fig. 2

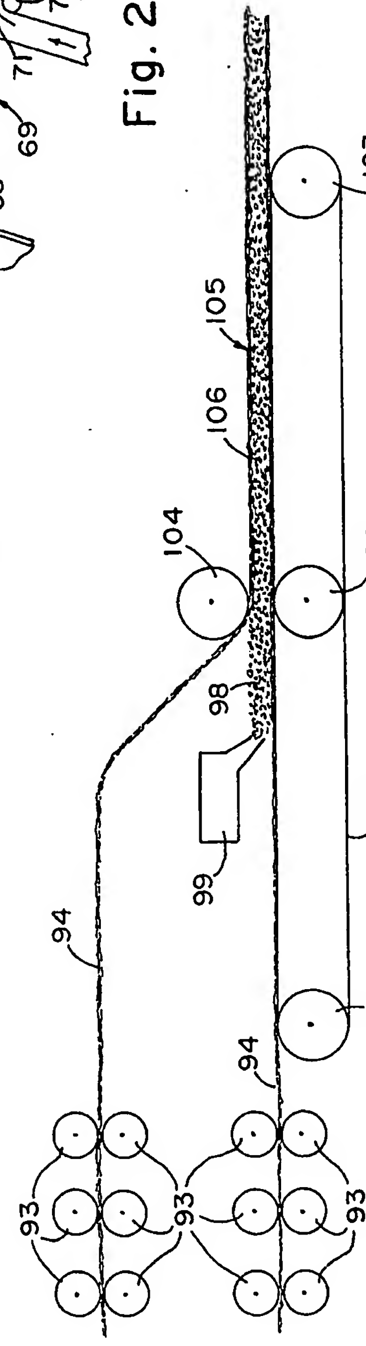

Fig. 3

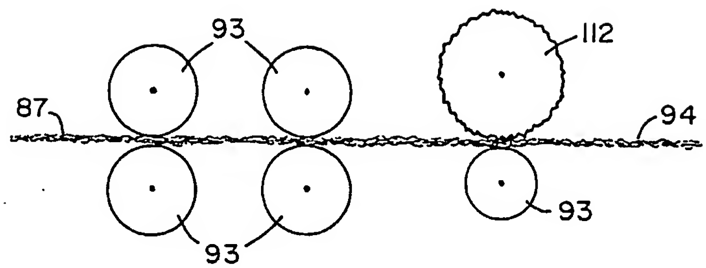

Fig. 5

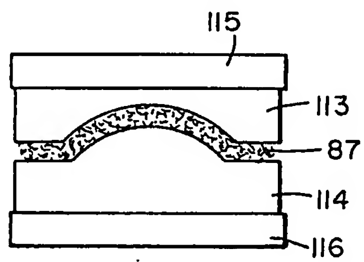

Fig. 6

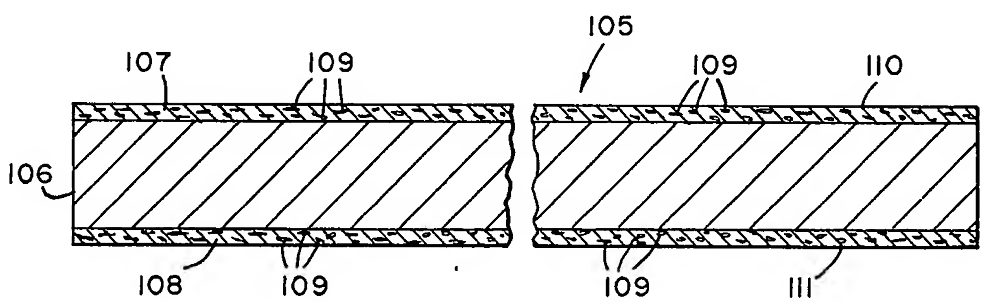

Fig. 4

SPECIFICATION

Fiber-reinforced cementitious sheets

Wall panels or wallboards made of rehydrated stucco conventionally comprise a gypsum core of uniform density sandwiched between two paper cover sheets. Such panels can be mass produced and erected so inexpensively that they have largely replaced prior building techniques using wood panels or plaster. As the usage of such wall board has expanded, however, specialty uses such as walls in high-rise office buildings and apartments have placed a premium on certain properties. Specifically, shaft walls used, for example, as elevator shafts, air return shafts, and stairwells are subject in some instances to very strict fire regulations. Thus there is a trend in municipal fire codes towards re-requiring a 0-0-0 fire rating for the exposed surface of elevator shafts, that is, having zero flame spread, zero smoke, and zero toxic gas generation.

It has not been possible to achieve such ratings as long as paper-covered wallboard is used, due to the combustibility or at least the smoke-generation capability, of the paper cover sheets. Such paper cover sheets are further troublesome in that they appreciably delay the drying time of the board during its manufacture.

A further problem characteristic of certain elevator shafts is that wind loading causes constant flexing of the wallboard. Thus, when used in such walls, the wallboard must have good flexural strength—a physical property not exhibited by rehydrated stucco alone due to its low modulus of rupture.

Some presently manufactured wallboard does include various ingredients which impart fire resistance to the board. For example, glass fibers on the order of one-half inch in length have been incorporated throughout the core of paper-covered gypsum wallboard used to line elevator shaft walls, on a weight percent basis of about 0.25% of the weight of the board. However, such fibers are not long enough to contribute significantly to the flexural strength of the board, as the concentration is insufficient, and at that length, the fibers' pull-out strength is insufficient.

Numerous methods have been developed through the years to combine glass fibers and gypsum in order to produce various articles such as reinforced gypsum wallboard. It was early realized that in order to develop good strength properties the glass fibers must be evenly dispersed and a gypsum matrix must be used which has high strength.

When glass fibers and gypsum are mixed in the form of an aqueous slurry, the length and amount of fibers which may be added are limited in order to prevent balling of the fiber during mixing. Excess water is also required to make the slurry sufficiently fluid to be formed into the desired article. The use of excess water reduces the strength of the gypsum matrix. This is disclosed in British Patent No. 1,204,541. In order to remove excess water, a means of applying suction and pressure to the formed board has been developed. This process is cumbersome and costly and not well adapted to high speed production.

A similar approach is illustrated in New Zealand Patent No. 155,679, which teaches a gypsum panel constructed with glass fibers of various lengths, dispersed generally throughout the rehydrated stucco. Such a construction has eliminated the need for a paper cover sheet. However, the process of making such panels is difficult, time-consuming, and involves the use of a large proportion of glass fibers, inasmuch as they are distributed more or less uniformly through the board or panel.

Another prior art process for producing glass fiber-containing gypsum board involves co-spraying discontinuous glass fibers and gypsum in an aqueous slurry onto a moving belt. Special low water demand plaster is used, or suction is used to remove the excess water. The major disadvantages of this process are that the fiber strands are not dispersed into individual filaments of which they are formed, thus reducing the efficiency of the fiber as a reinforcing agent, and that the fibers are not sufficiently mixed with the plaster.

Glass fiber mats have also been used to reinforce gypsum. These mats may be in the form of continuous or discontinuous, random oriented fiber, or as woven mats. The mats are saturated with gypsum using various means and methods. One method is described in Canadian Patent No. 993,773. The mats are fabricated with glass fiber strands each consisting of a plurality of glass fiber filaments. The gypsum slurry does not saturate the fiber strand and therefore the reinforcing efficiency of the fiber is reduced. Special low water demand gypsum such as alpha-calcium sulfate hemihydrate must be used to obtain high gypsum strength. Alternatively, excess water must be removed by means of suction.

In U. S. Patent No. 3,682,670, there is disclosed a process for preparing fiber-containing plaster products wherein glass wool and/or rock wool is carded, plaster powder added to the fibers as they are carded to provide a dry composition, and the dry mixture is then introduced into an excess of water to form a slurry which is subsequently cast in the form of boards. However, this process is somewhat dificient in that a large excess of water is introduced which must be subsequently removed by drying. Additionally, the carding process does not produce a good uniform mix of the fibers and plaster.

In U. S. Patent No. 1,862,318, a method is disclosed for producing plaster board containing cotton linters which comprises first

depositing a layer of gypsum on a moving belt, subsequently depositing the cotton linters thereover while carding, and finally sprinkling water over the layer thus formed and compressing the layer by rolling. In this method, because the gypsum and fibers are not premixed but, merely sprinkled onto the belt, a uniform layer is not produced.

The present invention provides a method for preparing a settable cementitious sheet which comprises mixing together in a moving air current a substantially dry water-settable cementitious material in finely particulate form with reinforcing fibers, depositing the mixture on an advancing foraminous surface to form a sheet, and applying water over the sheet in an amount sufficient to permit the cementitious material to set.

In embodiments of the invention, thin layers of a cementitious material such as rehydrated gypsum containing fibers such as glass fibers are prepared by mixing together in a flowing stream or current of gas, such as air, a substantially dry water-settable cementitious material, such as calcium sulfate hemihydrate, and fibers, such as glass fibers. The dry mixture is deposited by means of the flowing gas stream or current such as an air stream or current onto the surface of a moving belt which is preferrably foraminous or perforated, such as a screen, to permit the gas to pass therethrough while depositing the solid material in the form of a sheet. Subsequently water is sprayed onto the dry sheet in an amount sufficient to provide adequate plasticity and to completely set the calcium sulfate hemihydrate. Water is used slightly in excess of the stoichiometric amount for complete setting and for adequate plasticity, but without providing a large excess of water. The sheet thus formed is passed between compression rolls. An aqueous slurry of calcium sulfate hemihydrate may then be deposited over the compressed layer and a second compressed layer of gypsum identical to the bottom layer placed over the slurry. The gypsum of both the outer layers and of the core is then permitted to set and is subsequently dried in a kiln. The resulting product is fire-resistant, strong, and relatively light.

Throughout the specification and claims, wherever the term "stucco" is utilized, it is intended to have the meaning attributed to it by those skilled in the gypsum art. As used herein, the term "stucco" denotes calcined gypsym or calcium sulfate hemihydrate, either in the alpha or in the beta form.

The invention is illustrated below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a side elevational diagramatic view of an apparatus used to producle glass fiber-reinforced gypsum sheets according to the invention.

Figure 2 is an enlarged cross-sectional view of a portion of the apparatus of Fig. 1.

Figure 3 is a side elevational diagramatic view showing the apparatus utilized for producing gypsum board having glass fiber-reinforced outer layers.

Figure 4 is a cross-sectional view of glass fiber-reinforced gypsum board produced according to the method of the invention.

Figure 5 is a side elevational diagramatic view showing apparatus for increasing the density of the formed sheet and having means for embossing one surface of the sheet, and

Figure 6 is an end view of a mold which may be utilized to densify and shape the glass fiber-reinforced gypsum sheet.

Referring to Fig. 1, an apparatus is shown for carrying out a process of the present invention for forming a glass fiber-reinforced gypsum sheet, and comprises generally an apparatus 10 for preparing the glass fiber and mixing the fibers with stucco or calcium sulfate hemihydrate, and depositing the mixture on a screen by means of an air current; and an apparatus 11 for conveying the layer of glass fibers and stucco, applying a water spray thereto, and rolling the wet layer to increase its density.

The glass fiber preparation and stucco mixing apparatus 10 is generally a commercial apparatus produced by the Rando Machine Corporation, Macedon, New York, and is marketed under the Registered Trademark "RANDO". The apparatus is made up of several sections including a prefeeder 12, an open blender 13, a feeder 14, and a mixer and air depositing apparatus 15.

The prefeeder 12 comprises a housing 16, a floor apron 17 comprised of a pair of rolls 18 and 19, and an endless belt 20 mounted thereon. The apparatus further comprises an elevating apron 24 comprising a pair of rolls 25 and 26 and a barbed endless belt 27 mounted thereon. A stripper apron 28 is horizontally mounted in the upper portion of the chamber and comprises a pair of rolls 29 and 30 having a barbed endless belt 31 mounted thereon. A doffer roll 32 is mounted to cooperate with the elevating apron 24 to remove glass fibers from the surface thereof. An electric motor 33 is operatively connected to drive the various endless belts. An anti-static spray nozzle 34 and associated equipment (not shown) are provided to prevent the formation of static charges which might cause the glass fibers to clump.

The fiber opener and blender 13 comprises a housing 36 having therein a floor apron 37 comprised of rolls 38, 39 and 40 and an endless belt 41 mounted thereover. Barbed worker rolls 42 and 43 cooperate with a stripper roll 44 to open up the cut glass strands of the clippings and separate them into individual fibers. A hopper cover 45 prevents the open fibers from escaping. A main cylinder 46 cooperates with small

worker rolls 47 and small stripper rolls 48 to further separate the glass fibers and transport the fibers to an air bush 49. Motors 50 are operatively connected to the various rolls and provide motor power. An anti-static spray nozzle 51 and associated equipment (not shown) prevents static charges from building up.

The feeder 14 comprises a fiber separator 52 and a floor apron 53 comprised of rolls 54 and 55 and having an endless belt 56 mounted thereon. A vertically positioned elevating apron 57 comprises a pair of rolls 58 and 59 and an endless conveying belt 60 mounted thereover, conveying the fibers to an upper portion of the chamber which contains a horizontally mounted stripper apron 61 mounted on rolls 62 and 63 and having a barbed endless belt 64 mounted thereon.

As shown in greater detail in Fig. 2, an air bridge 65 connects to a feed mat condenser screen 66. A roll conveyor 68 cooperates with a feed plate 69 and feed rolls 70 to convey the fibers forward. A nose bar 71, lickerin 72 and saber roll 73 convey the fibers into a venturi chamber or duct 74 where a feeder 77 feeds stucco or other cementitious materials 78 into the venturi chamber 74 where the stucco is intimately mixed with the fibers by the air current passing through the venturi chamber 74. A condenser screen 79 in the form of an endless belt mounted on rolls is provided for collecting the air-blown mixture of glass fibers and cementitious material and conveys the formed web 87 to water treatment conveyor portion 83. Air current for mixing the stucco and fiber in the venturi chamber 74 and depositing the mixture on the condenser screen 79 is provided by a blowers 80 and 81. The air is conveyed to a dust collector 82 for removing stucco and fibers which may have passed through the condenser screen 79 by means of a duct 95.

The web passes to a water treatment conveyor system 83 comprising rolls 84 and 85, and an endless belt 86 mounted thereover. A water spray 92 is provided by means of a water duct 90 and a nozzle 91. The water treated web 87 then passes through densification rolls 93 to form a densified fiber-reinforced gypsum sheet 94.

In operation chopped glass fiber strands are introduced into the prefeeder 12 where, after preliminary processing, they are introduced into the fiber opener and blender 13. Here the various barbed rolls open up the glass fiber strands and free the individual glass fibers. The fibers are then conveyed to the feeder 14 where they are ultimately introduced into the venturi duct 74. The cementitious mixture such as stucco 78 is fed from the feeder 77 into the venturi chamber 74, where it is intimately mixed by the air stream with the glass fibers. The mixture is then deposited on the condenser screen 79. A vacuum is maintained below the screen for directing the air stream through the screen. The deposited web comprising glass fibers and stucco is then conveyed by the condenser screen 79 to the water treatment conveyor system 83, where water is sprayed over the web in an amount just sufficient to permit the stucco to become hydrated and to form set gypsum or calcium sulfate dihydrate. Only a very slight excess of water if any need be used to provide suitable plasticity. The water-treated web then passes through densification rollers and subsequently sets to a very hard dense sheet of glass fiber-reinforced gypsum, and is subsequently dried.

Referring to Fig. 3, an apparatus is shown which is used to apply two glass fiber-reinforced sheets 94 to the upper and lower surfaces of a deposited gypsum slurry. The apparatus comprises a moving endless belt 100 mounted on rolls 101, 102 and 103. Additionally a compression roll 104 is mounted for compressing the two glass fiber-reinforced sheets 94 against the gypsum slurry.

In operation two glass fiber-reinforced sheets 94 as formed by the apparatus of Fig. 1 are introduced into the apparatus, one sheet being supported on the moving belt 100. A conventional stucco slurry 98 is poured onto the lower sheet from a slurry mixer 99 and then the upper sheet 94 compressed against the slurry 98 by means of the rolls 102 and 104. The three layered structure is then permitted to set, and the excess water subsequently evaporated in a kiln.

Referring to Fig. 4, a portion of a three layered structure 105 is shown in cross-section and comprises a core 106 and outer glass fiber-reinforced layers or sheets 107 and 108 similar to the sheet 94 shown in Fig. 3. In accordance with one aspect of the invention, the core 106 has a relatively lower density and is substantially free of glass fibers, while the reinforced layers or sheets 107 and 108 have glass fibers 109 dispersed throughout, and have a relatively higher density. In a preferred form the core is made of foamed beta calcium sulfate hemihydrate, while the outer layers 107 and 108 contain glass fibers and are made of either alpha or beta calcium sulfate hemihydrate. As disclosed above, the outer layers are rolled to increase their density. The outer surfaces 110 and 111 of the outer layers 107 and 108, respectively, are free of paper cover sheets, since, as a result of the densification rolling step, they acquire a very hard and strong surface. The entire board is highly fire-resistant and smoke-resistant, relatively light, and has excellent flexural strength.

Fig. 5 illustrates a subassembly for producing an embossed or textured surface on the outer surface of the sheet. The wetted sheet 87 is first passed through the densification rolls 93 and embossing roll 112 having a pattern on its surface operating against a

standard roll 93. The resulting sheet 94 has an embossed pattern on the surface which is to become the outer surface of a completed gypsum board.

Fig. 6 illustrates a means for forming the finished sheet 87 to any desirable form. The sheet 87 is placed between two complimentary mold forms 13 and 114 supported by press plattens 115 and 116. The assembly is placed in a pressure and the sheet 87 is wetted and molded to form and subsequently permitted to cure and to be dried.

EXAMPLES

The following examples are provided for illustrative purposes only and are not intended to be limiting.

Example 1.—Preparation of glass fiber-reinforced gypsum sheet.

Glass fiber strands cut to one half inch in length were processed to separate the strands into individual fibers having a diameter of about 0.00025 inch. The glass fibers were mixed together in a moving air current with beta calcium sulfate hemihydrate in a proportion wherein the glass fiber was present in an amount of ten percent (10%) by weight of the total glass and hemihydrate. The glass fibers and hemihydrate were mixed together in a moving air stream and the mixture deposited on a moving screen belt. The dry deposited sheet was wetted by a water spray wherein approximately thirty-five (35) pounds of water per one hundred (100) pounds of calcium sulfate hemihydrate were utilized. The sheet was densified by passing between two sets of rolls having a nip pressure of 118 lb/linear inch. After densification, the hemihydrate of the sheet was allowed to hydrate or set. The sheet was then dried to a constant weight at 110° F. The density of the sheet was about 75 lbs. per cubic foot and the thickness 0.030 inch.

Specimens were prepared from the sheet for tensile strength evaluation. The prepared specimens were 12 inches long, and 3 inches wide at each end. They were necked down to 2 inches in width for an 8 inch length starting about 2 inches from each end of the specimen. The specimens were conditioned at 75° F. and fifty percent (50%) relative humidity before testing. An Instron testing machine was used. The specimens were positioned in the machine fixture so that the load was applied to the 2 inch wide area with a span of 8 inches. A tensile load of about 172 pounds with an elongation of 0.109 inch was required to cause failure of the material. A tensile load of about 163 pounds with an elongation of 0.074 inch was required to cause failure of a specimen of regular wallboard paper having a thickness of about 0.014 inch prepared in the same manner.

Example 2—Preparation of Gypsum Wallboard Panels

A pair of glass fiber-reinforced gypsum sheets were prepared as described in Example 1. Immediately after densification of the gypsum sheets but before setting of the stucco had taken place, one sheet was placed in the bottom of a mold. A standard beta calcium sulfate hemihydrate wallboard slurry was poured onto the top of the gypsum sheet. The second sheet was then placed on top of the slurry and the structure was consolidated between rolls. The finished panel was about one-half inch thick. The dry density of the core was 45.4 pounds per cubic foot. Conventional accelerator and retarder materials were used in both the glass fiber containing gypsum sheets and the core slurry, and the compositions were so adjusted as to permit substantially simultaneous hydration or setting of the calcium sulfate hemihydrate in both the core and the outer sheets. In this manner a very good bond resulted between the layers as a result of the inner growth of crystals at the layer interfaces even though conventional starch binder was omitted. After hydration or setting was complete, the panel was dried.

Specimens measuring 6 × 14 inches were cut from the panel. The specimens were conditioned at 75° F. and 50% relative humidity before testing. The bending or transfer strength was determined by placing the specimen onto supports spaced 12 inches apart. A load was then applied from above at the center of the span causing the material to bend until failure. A load of 130 pounds causing a deflection of about 0.384 inch was applied before the specimen failed.

Example 3—Comparative Example.

A conventional gypsum panel having standard paper cover sheets but no glass fiber reinforcements was prepared. The stucco was set and dried as in the previous examples, and tested for transfer strength. With the conventional panel a bending load of only 108 pounds with a deflection of 0.234 inch was required to cause failure of the panel. The load test was made in the strong direction of the panel.

Example 4—Testing under High Humidity.

Panels as made in Examples 2 and 3 were tested for resistance to deflection under humid conditions. The 12 × 24 inch specimens in each case were supported across the 12 inch end and maintained at 90° F. and 90% relative humidity conditions. After ten (10) days the deflection or sag of each panel was tested. The panel prepared with glass fiber-reinforced outer sheets showed a deflection of 0.075 inch, whereas the conventional panel having paper cover sheets had deflected about 0.195 inch.

Although the invention has been described above in relation to the use of beta calcium sulfate hemihydrate as the settable cementitious material, the alpha form may also be used and for some purposes may yield superi-

or products. Moreover, other settable cementitious materials may be used, such as a mixture of alpha calcium sulfate hemihydrate and cement, conventional hydraulic cement such as portland cement, magnesium oxychloride, and related materials. High early strength portland cements may also be used. It is only necessary to use a material which is compatible with the particular fiber used. For example, if portland cement is used, an alkali-resistant glass fiber must be used.

The invention has also been described in terms of its use with glass fibers for reinforcement. However, other fibers such as polyester, acrylic, nylon, carbon, rock wool, asbestos fiber, etc., may be used. The fiber lengths may be from one-half to six inches, preferably one-half to two inches. Where glass fiber strands are utilized, the fibers should first be opened up in a machine 13 such as that described above and then conveyed to the fiber feeder 14 which meters the fiber into the air stream of the web former. The feeder 77 then meters the cementitious materials such as calcium sulfate hemihydrate into the air stream. With the apparatus shown and described, it is convenient to introduce the glass fibers into the air stream first, and then to introduce the calcium sulfate hemihydrate downstream from the introduction of the glass fibers. Alternatively, the calcium sulfate hemihydrate may be introduced into the air stream first followed by the glass fiber downstream. In another satisfactory variation, the glass fibers and the calcium sulfate hemihydrate may be simultaneously introduced at the same position of the air stream. The important consideration is that the fibers and the calcium sulfate hemihydrate be uniformly blended within the air stream before they are deposited onto the traveling condenser screen 79 where the web is formed.

In utilizing the rolls 93, various roll coatings may be applied to facilitate release of the sheet material passing therethrough. Roll coating such as Teflon, chromium plating or steel may be used depending on the type of sheet surface desired. Heating the rolls may reduce the tendency for the sheets to stick to the rolls. In such a process a temperature of about 150° F. may be utilized. This temperature may be increased with increased production rates.

The glass fiber reinforced gypsum sheets may be made in various thicknesses. Preferred thicknesses are from about .010 inch to about .250 inch. The sheets may be used after hydration and drying for various purposes such as for applying to a plaster wall. Alternatively, a pair of sheets may be utilized with a gypsum slurry to form a structure such as shown and described above. In forming such a structure, it is preferred to utilize the sheets after pressing but before setting for application to the gypsum slurry core. The outer sheets then set at approximately the same time as the core and excellent adhesion is provided between the sheets and the core without the addition of bonding agents such as starch. Alternatively, the sheets may be fabricated separately and permitted to set and dry. The sheets may then be applied to a wet gypsum core slurry. Alternatively, the set and dry sheets may be applied to set core by means of an adhesive. After the laminated board is completed, it may be cut to the desired length in a conventional manner.

Where it is desired that the glass fiber-reinforced gypsum sheet have a decorative pattern, the sheet may be passed through an embossing roll before it is set, as illustrated in Fig. 5. Patterns such as wood grain, brick, etc., may be embossed into the surface of the sheet. The embossing is completd before hydration of the hemihydrate takes place. Subsequently the material is hydrated and dried. If the embossed sheet is to be utilized for making a laminated board, after embossing the sheet is applied to a calcium sulfate hemihydrate slurry for forming a core, and the sheet and core then hydrated and dried together.

Densification of the glass fiber-reinforced sheet may be accomplished by means other than rolls. As shown in Fig. 6, the dry sheet of glass fiber and stucco may be removed from the collector screen, placed onto the base of a mold and sprayed with sufficient water to hydrate the stucco and to render the sheet somewhat plastic. A matching section of the mold is then placed on top of the wetted sheet, the assembly placed between press plattens 115 and 116 and a force is applied to compact the sheets. A force of about 50 pounds per square inch is satisfactory, but the force may be varied to develop the desired density. With this process the sheet is simultaneously densified and molded into various desired shapes.

The process of the present invention can have advantages over prior art processes. First, because the fibers and dry cementitious material is mixed in an air stream, excellent mixing is possible without any clumping of the fibers. The problem of separating the strands or tufts of fiber into individual filaments is overcome by processing the fiber before it is mixed with the stucco and then suspending the filaments in an air stream. When the stucco is then fed into the air stream thorough blending of the fiber and gypsum is possible without any clumping.

Because the sheet of glass fiber and stucco is formed in the dry state, it is unnecessary to use a large amount of water to fluidize the material. Only sufficient water need be utilized to stoichiometrically hydrate the stucco and to make it sufficiently plastic so that it can be densified. The ability to use varying amounts of water and to densify the sprayed sheet to varying degrees permits the production of

glass fiber-reinforced gypsum sheet with a wide range of properties. If high tensile strengths are desired, the gypsum matrix sheet should be densified to a high degree. However, for some applications as for example the fabrication of art objects, a high tensile strength is not required but a more desirable low density article may be produced which has good impact and crack-resistance. To achieve this, higher amounts of water and lower densification pressure may be used. In the fabrication of calcium sulfate dihydrate sheets, additives are commonly added to control the rate of hydration. Additionally additives to increase the plasticity of the mix may be used. Polymers may also be used to increase the toughness of the article or to improve painting properties. All the conventional additives may be used in the present process to the extent that they are compatible with the particular fiber used. The additives may be blended with the dry stucco, or, those which are water soluble, may be added to the water used to wet the sheet.

In producing products according to the invention, various glass fiber parameters may be utilized. For example, the amounts of glass fiber used may be from 3–25% based on the weight of the dry formed sheet. The preferred range is from 6–10%. The glass fiber length may be from one half to six inches. A preferred length is from one to three inches. Glass fibers having diameters of .00023 to .007 inch may be utilized. A preferred range is .00025 to .00038 inch. The water to gypsum hemihydrate ratio may be from .25 to .60 by weight. A preferred ratio is .30 to .45.

The introduction of the cementitious setting material into the moving air stream and the co-deposition of the mixture contained in the air stream on a moving foraminous screen can give a web of fibers and cementitious material in very uniform distribution. When vacuum is applied at the leeward side of the stream, the fibers may be deposited with an orientation wherein they are somewhat oblique to the plane of the web, and this causes vertical interweaving of the fibers to produce a material of greater perpendicular tensile strength. Additionally, the step of spraying water onto the moving web in an amount which is not materially greater than the stoichiometric amount conserves on energy required for drying the material and also results in a material of greater strength because large excesses of water are not required to provide the necessary conventional fluidity of the mixture, since the sheet is dry formed and can be densified or further formed with the use of relatively small amounts of water. Additionally, when two sheets according to the invention are bonded to a gypsum core, no starch need to utilized for bonding.

It is to be understood that the invention is not to be limited to the exact details of composition, materials or operation shown or described, as obvious modifications and equivalents will be apparent to one skilled in the art.

CLAIMS

1. A method for preparing a settable cementitious sheet which comprises mixing together in a moving air current a substantially dry water-settable cementitious material in finely particulate form with reinforcing fibers, depositing the mixture on an advancing foraminous surface to for a sheet, and applying water over the sheet in an amount sufficient to permit the cementitious material to set.

2. A method according to claim 1 wherein the water is applied by spraying.

3. A method according to claim 1 or 2 wherein a vacuum is applied below the foraminous surface to assist in directing the cementitious material and fibers towards the surface.

4. A method according to claim 1, 2 or 3 wherein the unset sheet is densified by compression.

5. A method according to claim 4 wherein said sheet is densified by passing it between compression rolls.

6. A method according to any preceding claim wherein the amount of water is not substantially greater than the stoichiometric amount necessary to permit setting of the cementitious material.

7. A method according to any preceding claim wherein the thickness of the sheet is from about 0.010 inch to about 0.250 inch.

8. A method according to any preceding claim wherein a pattern is applied to one surface of the unset sheet by embossing.

9. A method according to any preceding claim wherein the cementitious material comprises calcium sulfate hemihydrate.

10. A method according to any preceding claim wherein the cementitious material comprises a mixture of alpha calcium sulfate hemihydrate and hydraulic cement.

11. A method according to any preceding claim wherein the cementitious material comprises a hydraulic cement.

12. A method according to claim 9 or 10 wherein the calcium sulfate hemihydrate is at least partially in the beta form.

13. A method according to claim 9 or 10 wherein the calcium sulfate hemihydrate is at least partially in the alpha form.

14. A method according to claim 10 or 11 wherein the cementitious material comprises very high early strength hydraulic cement.

15. A method according to any preceding claim wherein the fibers comprise glass fibers.

16. A method according to claim 15 wherein the glass fibers are ones formed by chopping glass fiber strands and subsequently opening the chopped strands into individual fibers.

17. A method according to any preceding claim which includes the steps of causing or permitting the cementitious material of the sheet to set.

18. A method according to claim 17 including drying any excess moisture from the set sheet.

19. A sheet obtained by a method according to claim 17 or 18.

20. A sheet according to claim 19 containing from about 3% to about 25% of fibers based on the dry weight of the sheet.

21. A sheet according to claim 20 containing from about 6% to about 10% of fibers based on the dry weight of the sheet.

22. A method for preparing a laminate which comprises forming a first sheet by a method according to any of claims 1 to 16, forming a second sheet by a method according to claim 16 depositing an aqueous slurry of a cementitious material over one of the sheets, placing the other of the sheets over the aqueous slurry, causing or permitting the sheets and slurry to set, and drying any excess water remaining in the resulting laminate.

23. A method for preparing a laminate which comprises forming a first sheet according to claim 19, 20 or 21, forming a second sheet by a method according to claim 19, 20 or 21, sandwiched between the sheets an aqueous slurry of cementitious material, causing or permitting the slurry to set, and drying any excess water remaining in the resulting laminate.

24. A method of forming a laminate which comprises forming a pair of dried sheets according to claim 19, 20 or 21 and adhering them to opposite sides of a set cementitious core.

25. A method according to claim 22 or 23 wherein the cementitious material of the slurry comprises calcium sulphate hemihydrate and/or hydraulic cement.

26. A method according to claim 25 wherein the cementitious material of the slurry comprises alpha- and/or beta-calcium sulphate hemihydrate.

27. A method according to claim 25 or 26 wherein the cementitious material of the slurry comprises very high early strength hydraulic cement.

28. A method according to claim 24 wherein the cementitious material of the slurry comprises gypsum and/or set hydraulic cement.

29. A laminate of a core of set cementitious material between a first dry sheet according to claim 19, 20 or 21 and a second dry sheet according to claim 19, 20 or 21.

30. A laminate obtained by a method according to any of claims 22 to 28.

31. A mould sheet according to claim 19, 20 or 21.

32. A method of forming a fiber-reinforced sheet, the method being substantially as hereinbefore described with reference to Figs. 1 and 2 of the accompanying drawings.

33. A method of forming a fiber-reinforced sheet, the method being substantially as hereinbefore described with reference to Figs. 1, 2 and 5 of the accompanying drawings.

34. A method of forming a fiber-reinforced sheet, the method being substantially as hereinbefore described in Example 1.

35. A method of forming a laminate, the method being substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

36. A method of forming a laminate, the method being substantially as hereinbefore described in Example 2.

37. A laminate substantially as hereinbefore described with reference to Fig. 4 of the accompanying drawings.

38. A fiber-reinforced sheet substantially as hereinbefore described in Example 1.

39. A fiber-reinforced sheet substantially as hereinbefore described with reference to Fig. 6 of the accompanying drawings.

40. A laminate substantially as hereinbefore described in Example 2.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon) Ltd.—1979.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.